Approximation to earth material from international normative

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Abstrat

For centuries, earth has been used as a construction material. Nevertheless, the normative in this matter is very scattered, and the most developed countries, to carry out a construction with this material implies a variety of technical and legal problems. In this paper we review, in an international level, the normative panorama about earth constructions. It analyzes ninety one standards and regulations of countries all around the five continents. These standards represent the state of art that normalizes the earth as a construction material.

In this research we analyze the international standards to earth construction, focusing on durability test (spray and drip erosion tests). It analyzes the differences between methods of test. Also we show all results about these tests in two types of compressed earth block

Key words: Normative, standard, earth-construction, international, test.

1. Introduction

For a long time the earth building has been abandoned as construction system. However, the innovation and research in this scope is increasing as time run, throughout Europe (especially agencies and institutions in France, Germany, Spain), Canada, USA or Latin America. In the most developed countries, the normative in this matter is very scattered and few concrete, for this there are large technical- legal problems to build with earth. If we study all international standards (Cid et al. 2011), it knows all details and technical properties of this material (Cañas Guerrero et al. 2007).

In this research we analyze the international standards to earth construction, focusing on the technical properties to durability. We analyze how the differences between tests influence in the results of the earth material.

2. Material and methods

We will develop a technical study of the different earth techniques that promote quality and technological innovation of building with earth (compressed earth blocks, rammed earth and adobe). All these normative (table 1) are documents that establish definitions, product requirements, implementation procedures, assessment and measures procedures and quality standards. The knowledge of this study could be very useful for the development of future standards and also as a reference for architects and engineers which work with earth.

One of the main aspects that we will analyze in this paper, is the durability of earth materials. The test procedures will be those ones proposed in the international normative to study the durability opposite to rain: spray erosion test (standards of New Zealand, Sri Lanka or India) and drip erosion test (standard of Spain). These test methods are applied to one block Spanish.

TABLE 1: Earth construction standards

Country	Standard	Organization	Technique			Country	Standard	Organization	Technique		
			A	CEB	RE				A	CEB	RE
African regional	ARS 670:1996	ARSO		X		Cameroon	NC 112: 2002	ANOR		X	
	ARS 671:1996						NC 113: 2002				
	ARS 672:1996						NC 114: 2002				
	ARS 673:1996					Colombia	NTC 5324	ICONTEC		X	
	ARS 674:1996					EEUU	NMAC, 14.7.4:2009	CID	X	X	X
	ARS 675:1996						ASTM E2392 M-10	ASTM	X	X	X
	ARS 676:1996					France	XP P13-901,2001	AFNOR		X	
	ARS 677:1996					India	IS 2110: 1980	BIS			X
	ARS 678:1996						IS 1725: 1982.	BIS		X	
	ARS 679:1996						IS 13827 : 1993	BIS	X		X
	ARS 680:1996					Italy	Ley nº 378:2004		X	X	X
	ARS 681:1996						L.R. 2/06 2 Ag. 2006				
	ARS 682:1996					Kenya	KS 02-1070: 1999	KEBS		X	
	ARS 683:1996					Nigeria	NIS 369:1997	SON		X	
Brazil	NBR 8491:1986.	ABNT		X		New Zealand	NZS 4297:1998	SNZ	X	X	X
	NBR 8492:1986.						NZS 4298:1998				
	NBR 10832:1989						NZS 4299:1999				
	NBR 10833:1989					Perú	NTE E 0.80:2000	SENCICO	X		
	NBR 10834:1994.						NTP 331.201:1979	INDECOPI	X		
	NBR 10835:1994						NTP 331.202:1979				
	NBR 10836:1994						NTP 331.203:1979				
	NBR 12023:1992					Senegal	NS 02-43:1999	ASN		X	
	NBR 12024:1992						NS 02-44:1999				
	NBR 12025:1990						NS 02-45:1999				
	NBR 13554:1996						NS 02-46:1999				
	NBR 13555:1996						NS 02-47:1999				
	NBR 13553:1996				X		NS 02-48:1999				
Burkina Faso	NBF 0.2-001:2009	FASANORM		X			NS 02-49:1999				
	NBF 0.2-002:2009						NS 02-50:1999				
	NBF 0.2-003:2009						NS 02-51:1999				
	NBF 0.2-004:2009						NS 02-52:1999				
	NBF 0.2-005:2009						NS 02-53:1999				
	NBF 0.2-006:2009						NS 02-54:1999				
	NBF 0.2-007:2009						NS 02-55:1999				
	NBF 0.2-008:2009						NS 02-56:1999				
Cameroon	NC 102: 2002	ANOR		X		Spain	UNE 41410:2008	AENOR		X	
	NC 103: 2002					Sri Lanka	SLS 1382-1:2009	SLSI		X	
	NC 104: 2002						SLS 1382-2:2009				
	NC 105: 2002						SLS 1382-3:2009				
	NC 106: 2002					Tunisia	NT 21.33:1996	INNORPI		X	
	NC 107: 2002						NT 21.35:1996				
	NC 108: 2002					Turkey	TS 537:1985	TSI			
	NC 109: 2002						TS 2514:1985		X		
	NC 110: 2002						TS 2515: 1985				
	NC 110: 2002 bis					Zimbabwe	SAZS 724:2001	SAZ			X
	NC 111: 2002										

A: Adobe; CEB: Compressed earth block; RE: Rammed earth

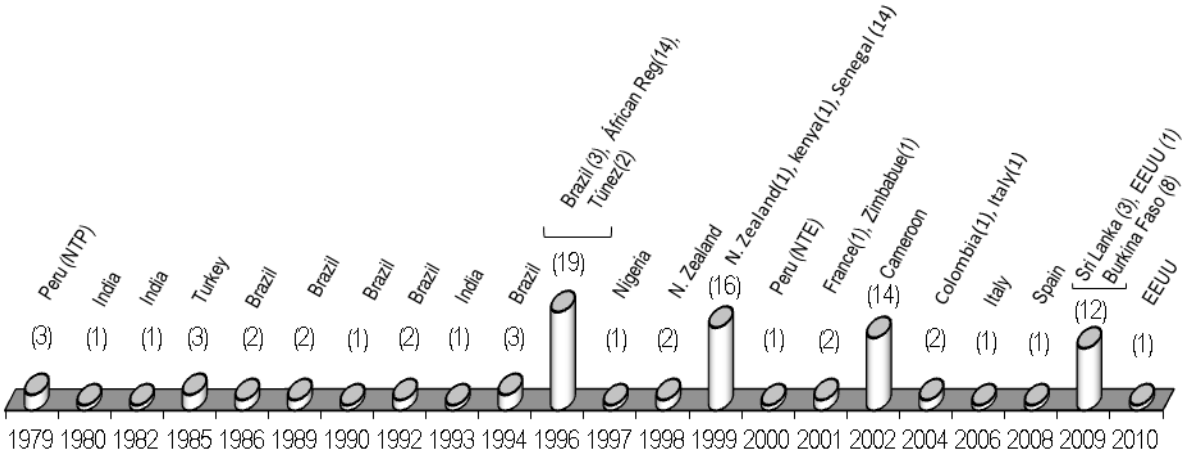

FIGURE 1: Earth standards according to publication year.

For the application of international test, it develops two prototypes that have great versatility in the system allowing the validation of all the technical specifications proposed in the analyzed normative documents. In the spray erosion test, pressures, distances of application and/or area of the exposed zone can be changed. In the drip erosion test we can change the height of application and/or the quantity of water.

3. Results/Conclusions

3.1. International standards.

In this article is studied the normative frame about earth construction in an international range, for this purpose we have analyzed ninety one standards and regulations of all the countries around the five continents. All this study represents the state of art that normalizes the earth as a construction material. In the figure 2, it shows the percentages of earth standars according to the main techniques of earth construction (adobe, compressed earth block- CEB and rammed earth). A large part of documents (74%) discuss a single construction technique (adobe or compressed earth block or rammed earth). Twenty seven percent of standards contemplate earth exclusively as a stabilized material.

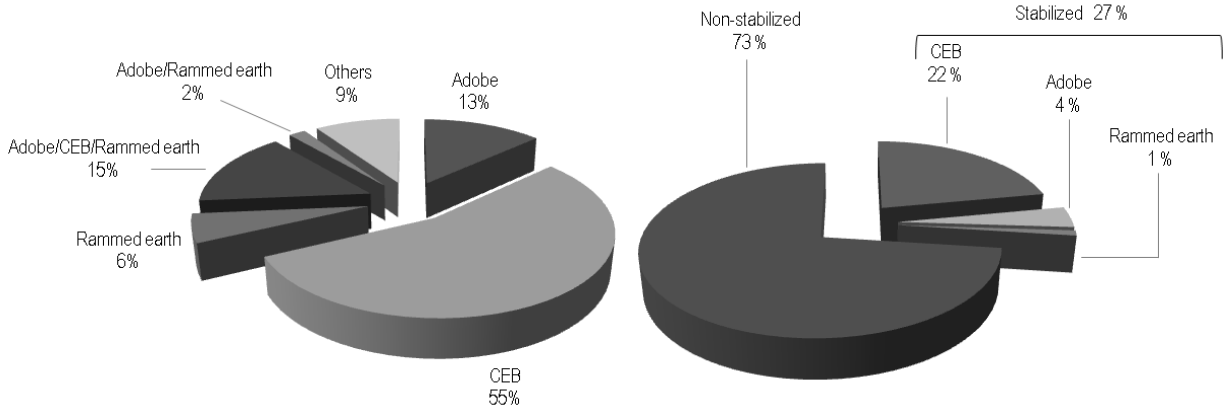

FIGURE 2: Distribution of earth techniques according to international standards

3.2. Test of durability.

After studying the normative international panorama, regulations or standards, regarding to durability of the earth systems opposite to the erosion of water are analyzed. The tests currently used to check the effect of water on this kind of material are spray erosion test (BIS 1982; SNZ 1998a; SNZ 1998b; SNZ 1999; SLSI 2009a; SLSI 2009b; SLSI 2009c) and drip erosion test (AENOR 2008). Two kind of compressed earth blocks are used in this research, non-stabilized block (CEB 1) and other stabilized block (CEB 2). The purpose of stabilizing earth-based materials is to improve their resistance to the detrimental effects of water.

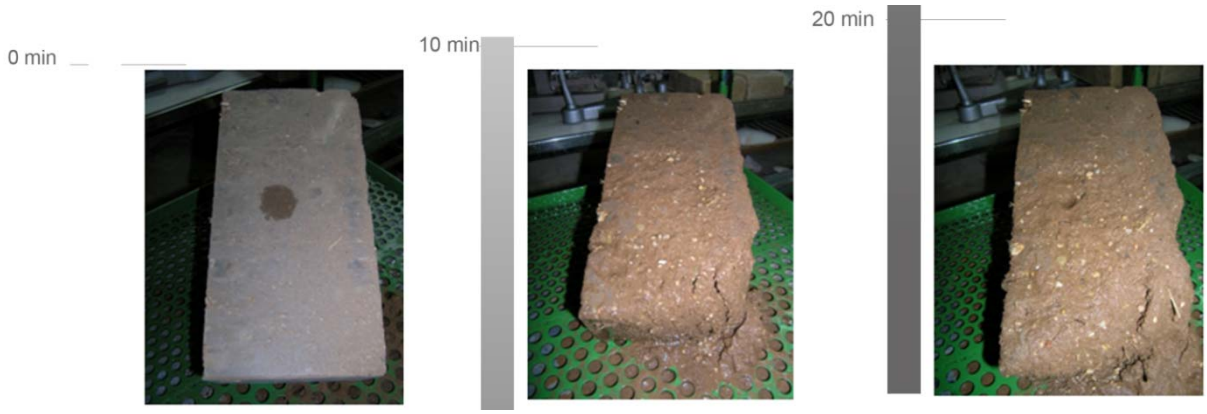

FIGURE 3: Drip erosion test (non-stabilized block)

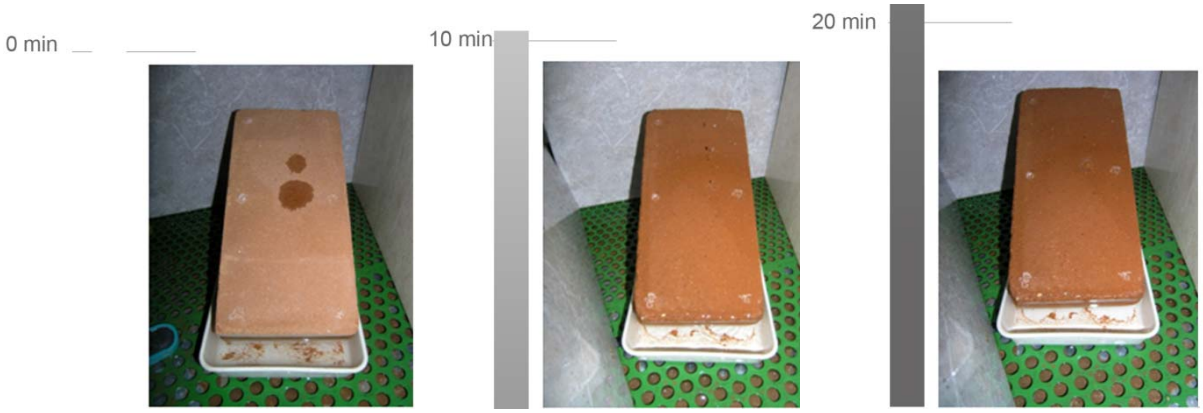

FIGURE 4: Drip erosion test (stabilized block)

Drip erosion test - is a valid method for CEB 1, whilst for stabilized blocks (CEB 2), not quantifiable differences are found in their results (Figure 3-4)

Spray erosion test- When applying this test, all CEB 2 (stabilized block) are apt according to the technical specifications of the different methods. Instead, CEB 1 (unstabilized block), does not pass the conformity criteria. Comparing the different test procedures (spray erosion test) method NZS (standards of New Zealand), method SLS (standards of Sri Lanka) and method IS (standards of India), is a more aggressive (method IS) than the rest of test procedures (method NZS and SLS). These three methods have different evaluation criteria, thus it is impossible to compare results.

The lack of unified criteria in the tests produces differences in the results obtained depending on the method used. Spray erosion test (standard India) is bigger than when other proceedings are applied (standards of New Zealand or Sri Lanka).

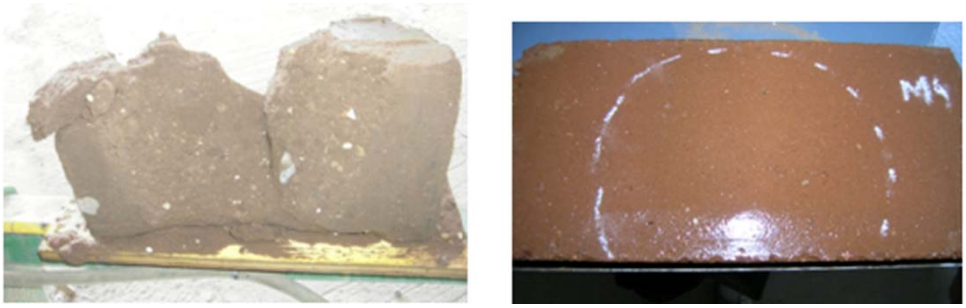

FIGURE 5: Spray erosion test, non-stabilized and stabilized blocks

This analysis of the test proceedings could be a reference in the writing of future normative documents for all world.

Knowledges

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